Good Practice

Guide 97

ENERGY EFFICIENCY IN NEW HOUSING

Detailing for designers and building professionals

PITCHED ROOFS

"A U-value of 0.25 W/m²K has been chosen as a target value for pitched roofs of energy efficient new dwellings"

BEST PRACTICE PROGRAMME

Energy Efficiency Office

DEPARTMENT OF THE ENVIRONMENT

BEST PRACTICE PROGRAMME

Contents

Foreword

This Guide is one of a series produced by BRECSU for the EEO under the title *Energy efficiency in new housing: detailing for designers and building professionals*. The other Guides in this series are:

- Good Practice Guide 93 – *Key detailing principles*
- Good Practice Guide 94 – *Ground floors*
- Good Practice Guide 95 – *External cavity walls*
- Good Practice Guide 96 – *Windows and external doors.*

To complement these Good Practice Guides there is a companion series with the title *Energy efficiency in new housing: site practice for tradesmen.* The following are relevant to pitched roofs:

- Good Practice Guide 109 – *Insulating a conventional pitched roof*
- Good Practice Guide 110 – *Insulating a room in the roof.*

A U-value of 0.25 W/m²K, which can be achieved cost-effectively, has been chosen as a target value for pitched roofs of energy efficient new dwellings and has been used throughout this Guide.

The structure of the Guide

This Guide is divided into three sections. The first two deal with the main ways of insulating pitched roofs:

- roofs with a loft
- room-in-the-roof designs.

Section 97.3 deals with services in roof spaces.

To make comparisons between alternative methods of insulation easier, each Section is structured in the same way.

- Introduction with 'Features' box
- Construction options
- The main technical risks
- An explanation of each technical risk in turn, with a list of the key detailing points to either avoid, or minimise the risk
- Specification Notes
- Buildability Points

Acknowledgements

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ENERGY EFFICIENCY IN NEW HOUSING

Detailing for designers and building professionals

INTRODUCTION

This Section deals with pitched roofs with loft spaces, insulated at ceiling joist level. Room-in-the-roof designs are dealt with separately in Section 97.2.

The simple pitched roof, using trussed rafters, is the dominant type of roof construction in new housing and is well known by designers. Nevertheless, there are a number of technical risks that need to be addressed if problems are to be avoided. This Section sets out the detailing points that building designers need to take into account if problems of condensation, thermal bridging, and ineffective insulation are to be avoided.

Technical risks associated with services and service penetrations through the ceiling are covered in Section 97.3.

CONSTRUCTION OPTIONS

The main construction options of roof shape, pitch and type of roof covering have little effect on the main technical risks listed.

The basic pitched and tiled roof using trussed rafters is usually insulated at ceiling level with mineral wool quilt, although blown mineral wool and cellulose fibre are also suitable. To avoid a thermal bridge at ceiling joists, it is advisable to lay quilt in two layers, the first between the ceiling joists, the second across the joists.

FEATURES

- It is easy to insulate a pitched roof with a loft to a high standard.
- It is essential to cross-ventilate the loft space to prevent the risk of condensation.
- Battens should be fixed on top of ceiling joists to prevent access boarding compressing the insulation.
- Loft hatches should be insulated and fitted with draughtseals.
- Loft insulation should be taken over the wall plate and abut wall insulation to avoid thermal bridging.

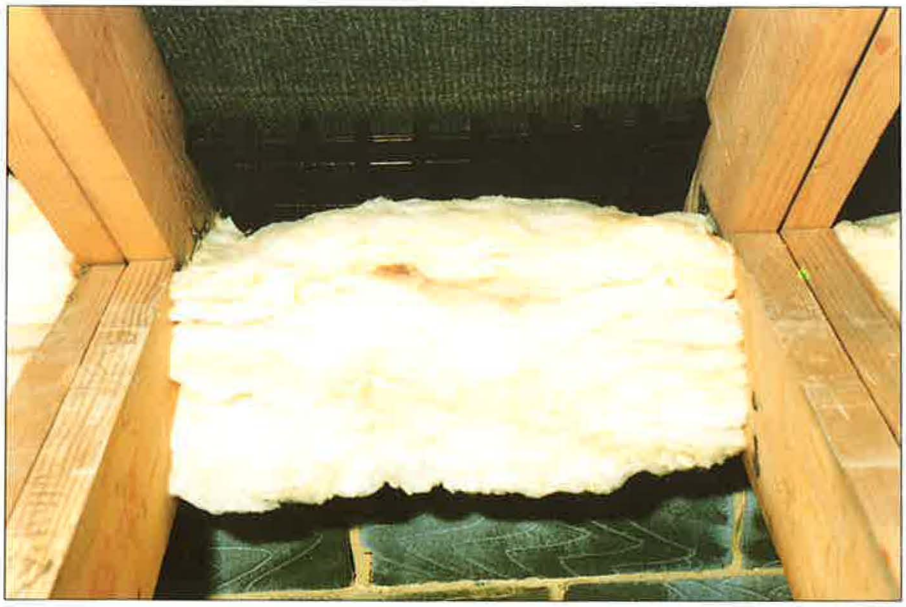
MAIN TECHNICAL RISKS

The main technical risks are:

- **condensation** if there is insufficient ventilation through the loft space to remove moist air infiltrating from the dwelling below
- **thermal bridging** at the junction with the eaves and gable walls
- **insulation compressed** by access boarding when the depth of the ceiling joists is less than the insulation thickness.

PITCHED ROOFS

Roofs with a loft



A short length of insulation installed over wall plate and below ventilation tray to avoid a thermal bridge

"It is easy to insulate a pitched roof with a loft to a high standard. Loft insulation should be taken over the wall plate and abut wall insulation to avoid thermal bridging"

DETAILING TO AVOID CONDENSATION IN THE LOFT SPACE

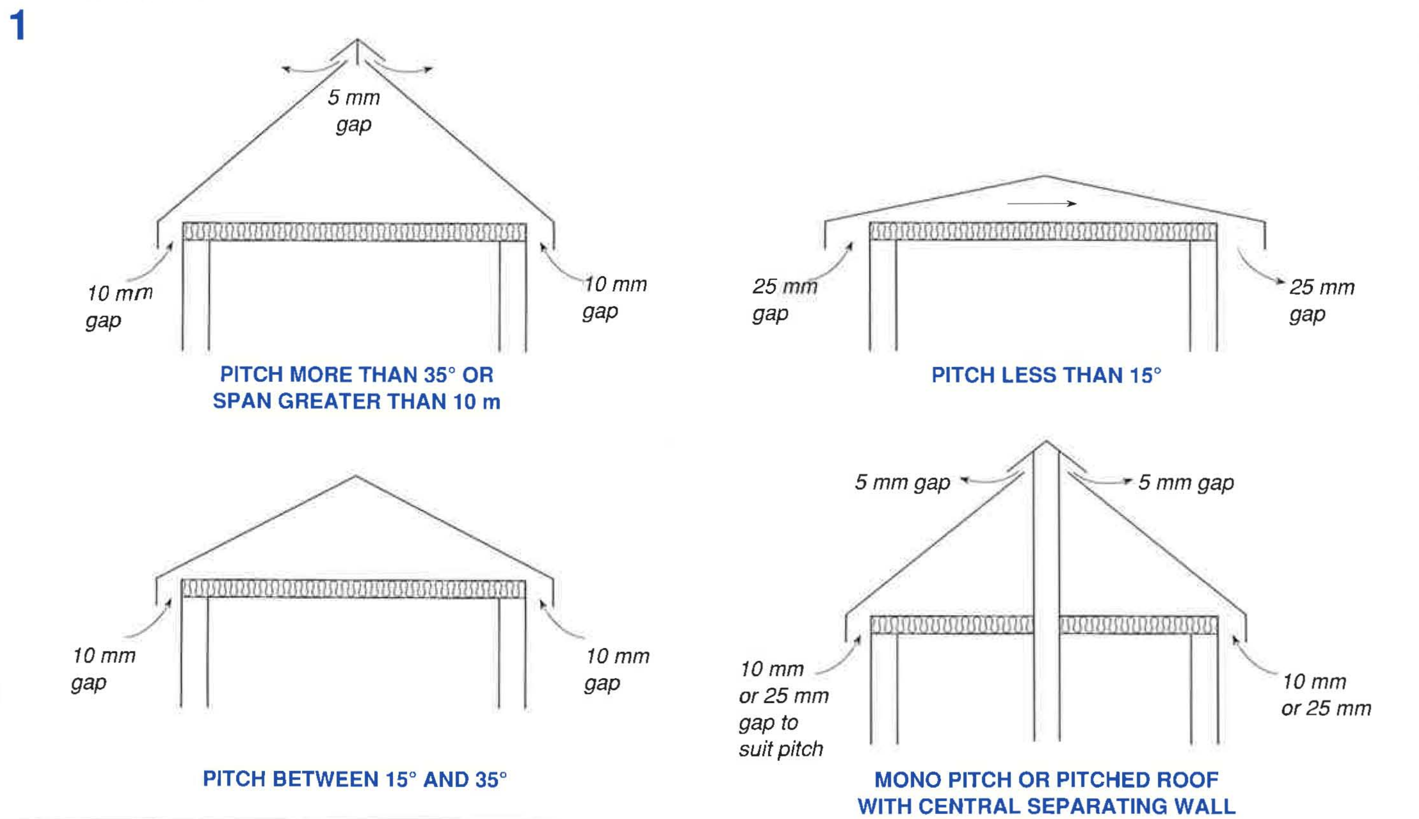
Condensation in the loft space can be avoided by:

- sealing all holes and gaps in the ceiling to restrict the amount of water vapour entering the loft space from the dwelling, and
- providing adequate ventilation of the loft space to the outside air.

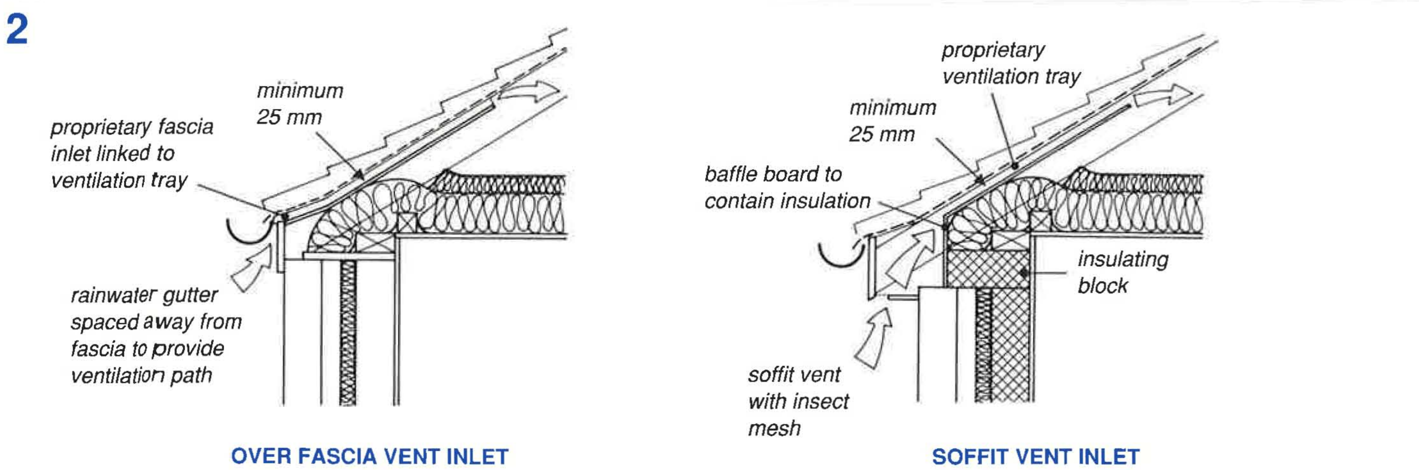
The **key detailing points** follow.

- Provide cross-ventilation of the loft space according to roof pitch, span and configuration (see Diagram 1). Ridge ventilation is advisable when the pitch is greater than 35° or the span is greater than 10 m.
- The ventilation openings should prevent the entry of insects. A 3 or 4 mm mesh across the ventilation holes is usually sufficient and is usually incorporated in proprietary ventilation grilles.
- Use a board or proprietary eaves ventilation tray to ensure that the ventilation path is not blocked by the loft insulation. There should be a minimum 25 mm airpath between the sarking felt and the insulation, irrespective of roof pitch (see Diagram 2).
- Draughtseal the loft hatch and provide catches or bolts to compress the draughtseal and prevent air leakage from wind uplift (see Diagram 3).
- Do not locate balanced flue outlets immediately below the eaves ventilation.

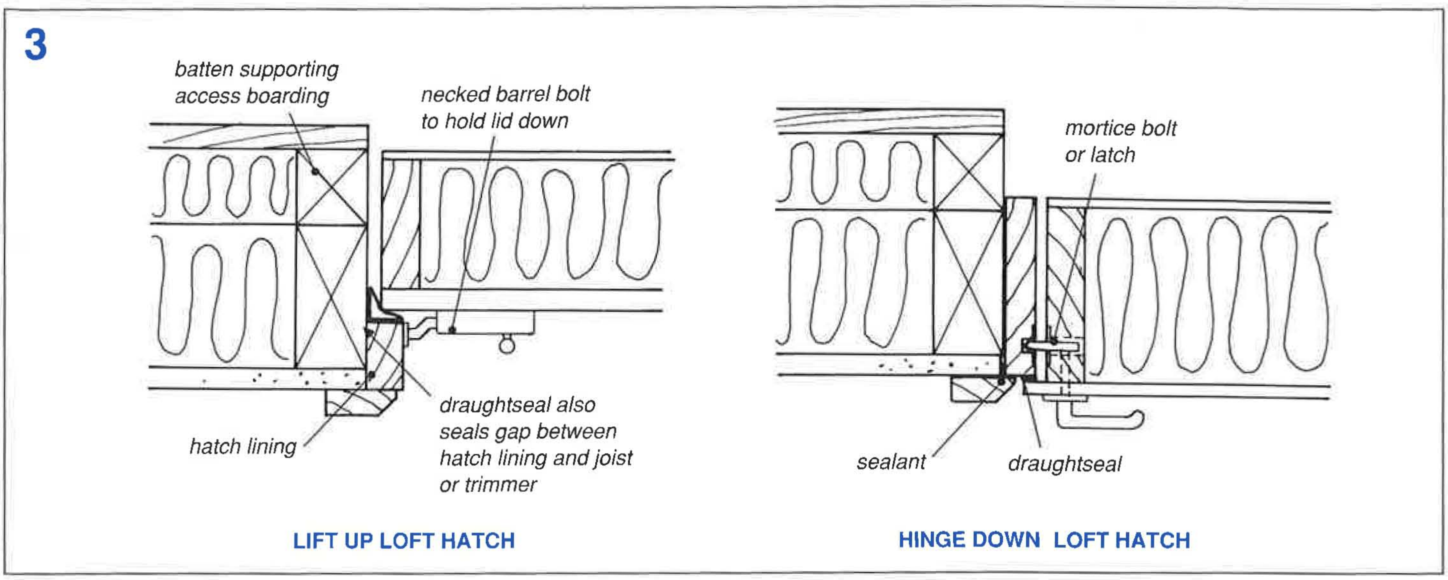
A proprietary soffit ventilator



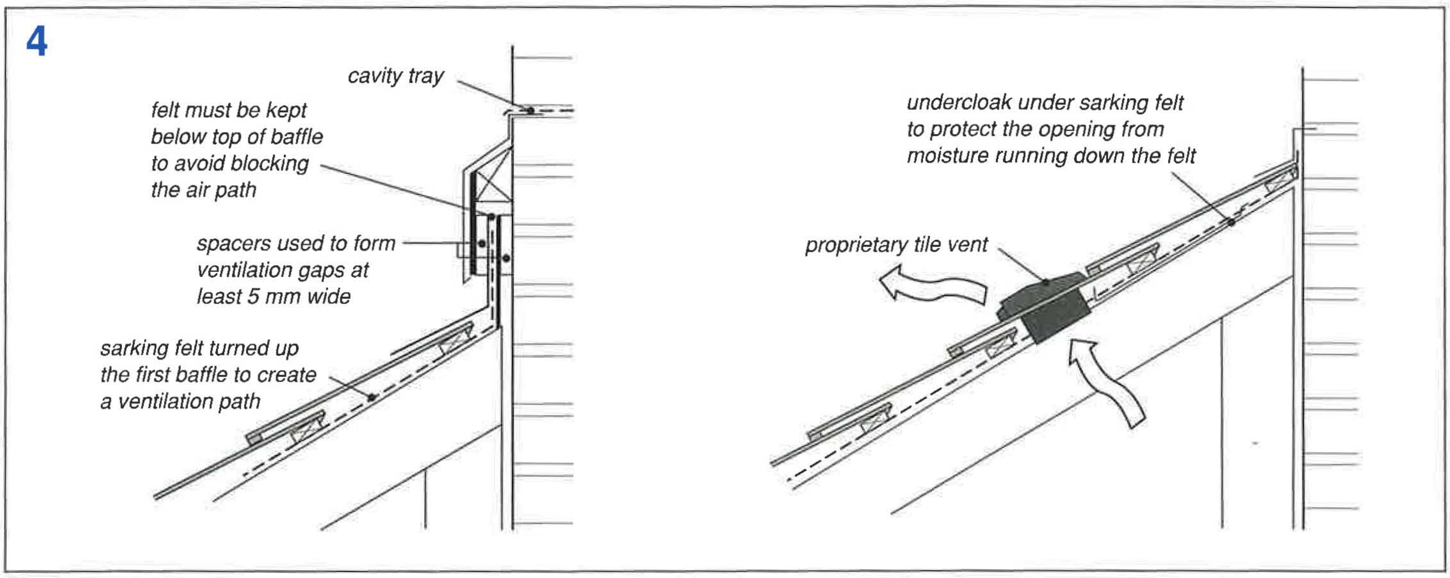
Provision of cross-ventilation to pitched roofs



Alternative methods of providing eaves ventilation



Minimising air leakage at the loft hatch



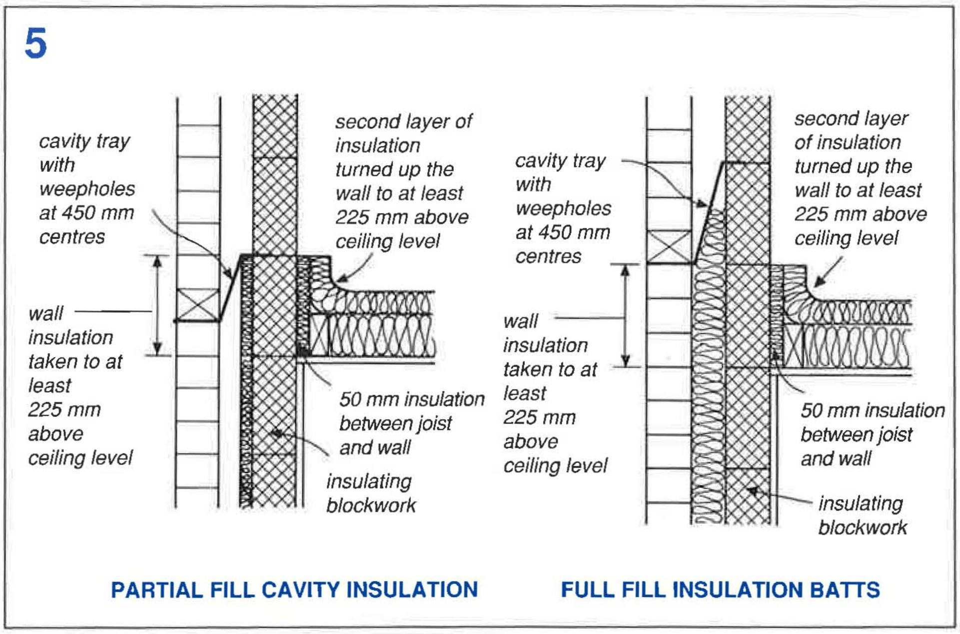
Alternative methods of providing ventilation at mono pitch roof/wall junction

DETAILING TO AVOID THERMAL BRIDGING

Most of the thermal bridge detailing problems occur at the eaves and the roof/gable junction.

The **key detailing points** follow.

- Cavity wall insulation in gable walls should be taken up to at least 225 mm above ceiling level and protected by a cavity tray (see Diagram 5).
- The gap between gable walls or separating walls and the first ceiling joist should be insulated and taken up the wall to the same level as the cavity wall insulation (see Diagram 5).
- The second layer of insulation should also be taken up the gable wall.
- The inner leaf should be insulating blockwork, with a thermal conductivity no greater than 0.30 W/m•K.
- The loft hatch should be insulated. It should preferably have the same insulation value as the main roof area. Proprietary loft hatches are available which give U-values from about 0.6 to 0.45 W/m²K.



Detailing to avoid a thermal bridge at gable wall

- Detail the eaves so that the roof insulation covers the wall plate and meets or overlaps the wall insulation (see Diagram 6).
- Where insulation quilt is draped over the wall plate, high ventilation rates within the boxed eaves can reduce the effectiveness of the insulation due to cold air blowing through the quilt. Fixing a vertical baffle board within the boxed eaves can overcome this problem (see Diagram 7).

DETAILING TO AVOID INSULATION BEING COMPRESSED

The thickness of roof insulation is often greater than the depth of ceiling joists. This can present problems with regard to access within the loft space. To prevent compression of the insulation by boarding, provide battens on top of the ceiling joists to raise the boarding above the level of the insulation (see Diagram 3).

SPECIFICATION NOTES

- Where proprietary eaves ventilation trays are specified, check that they provide a clear 25 mm airpath between the insulation and the sarking felt (see Diagram 2).
- Ensuring that the loft insulation covers the wall plate can be difficult to accomplish where space at the eaves is restricted. To give more space, specify a trussed rafter with additional blocking so that the setting out point of the truss can be cantilevered up to 150 mm outside the wall plate (see Diagram 6).

BUILDABILITY POINTS

- Some eaves details require the loft insulation to be draped over the wall plate in order to abut the wall insulation, and avoid a thermal bridge. This cannot be done once the roof has been tiled. It is necessary for short lengths of insulation to be placed in position at the same time that the eaves ventilation trays are fixed (see Diagram 7).
- Because of the obstruction caused by trussed rafter members, blown insulation may be easier than quilt to lay to thicknesses greater than the joist thickness.
- When mineral wool quilt is laid in two layers, or when blown insulation is laid to a depth greater than the joist thickness, it is necessary, in the interests of safety, to lay battens in those parts of the loft where access is likely to be needed.
- Where the insulation quilt above the wall plate has to be compressed significantly during installation, it can push up the ventilation tray causing the sarking felt above to bulge up between the rafters. This can obstruct the natural drainage paths along the sarking felt which are formed by the felt sagging between the rafters. Water running down the felt will collect behind the tiling battens, with a consequent increase in the risk of timber decay. A roof truss with a cantilevered setting out point (see Diagram 6) can allow the full thickness of insulation to be placed over the wall plate.
- The first roof truss should be spaced at least 50 mm from gable and separating walls so that there is sufficient space for insulation to be placed in the gap (see Diagram 5).

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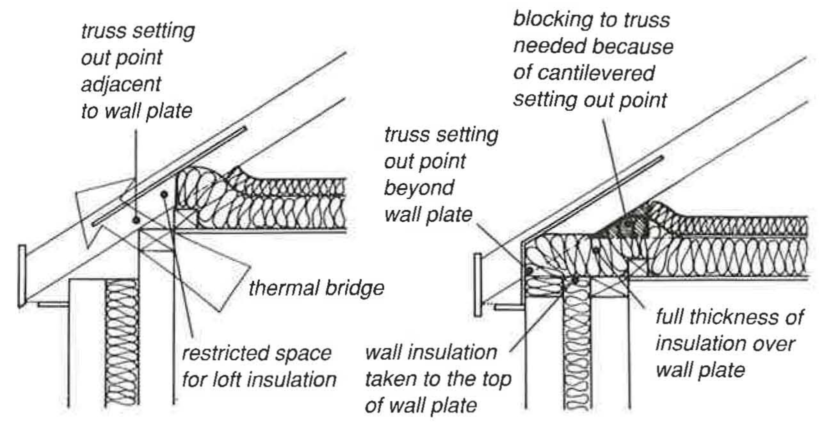

Method to avoid a thermal bridge at the eaves

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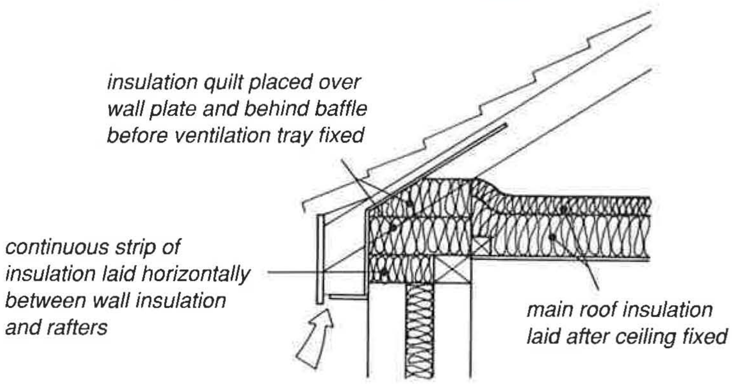
Fixing the baffle to prevent the cold air blowing through the eaves insulation

The ventilation tray just laps the baffle to enclose the insulation quilt



Ensuring the full thickness of loft insulation is draped over the wall plate

ENERGY EFFICIENCY IN NEW HOUSING

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PITCHED ROOFS

Room-in-the-roof designs

INTRODUCTION

This Section deals with pitched roofs with habitable rooms within the roof space.

Room-in-the-roof designs are seen as an economic way of providing extra living accommodation and most trussed rafter manufacturers have a range of 'attic truss' designs to suit a variety of spans and roof pitches. Rooms can be lit and ventilated by dormer windows or roof windows.

Traditionally, the principle of having a ventilated space on the cold side of the insulation (cold roof) has been promoted for all types of pitched roof.

However, another method which has a proven record over many years, particularly in Scotland, uses insulated sarking above the rafters, creating a warm roof design.

The **key detailing points** for room-in-the-roof designs follow.

- The reconciliation of roof bracing requirements with the provision of 'inter-rafter' insulation.
- The layout of trussed rafters in relation to skylight or dormer openings.
- Co-ordinating skylight dimensions with truss spacing and design.
- The feasibility of providing ventilation outlets where 'hipped rafters', dormer windows or roof windows restrict the passage of ventilation air above 'inter-rafter' insulation.
- Maintaining the continuity of vapour control layers, particularly when it is intended to run services behind the plasterboard lining or provide eaves storage cupboards.

FEATURES

- It is a convenient method of providing living accommodation, particularly bedrooms and bath or shower rooms within the roof, thus making the most of the enclosed volume.
- Roofs with dormer windows can accommodate either 'ventilated roof' or 'insulated sarking' construction.
- Satisfactory detailing around skylights is most easily achieved with an insulated sarking roof construction.
- When attic trussed rafters are used, bracing requirements of the truss manufacturers should be followed to resist buckling.
- To accommodate the required thickness of insulation, it may be necessary to increase the effective depth of the rafter by adding timber battens on the inside.
- Higher standards of insulation as well as insulation overlap can be achieved by supplementing 'inter-rafter' insulation with a layer of insulating plasterboard across the inner surface of the rafters.
- Services can be accommodated behind the plasterboard lining with suitable protection against damage.

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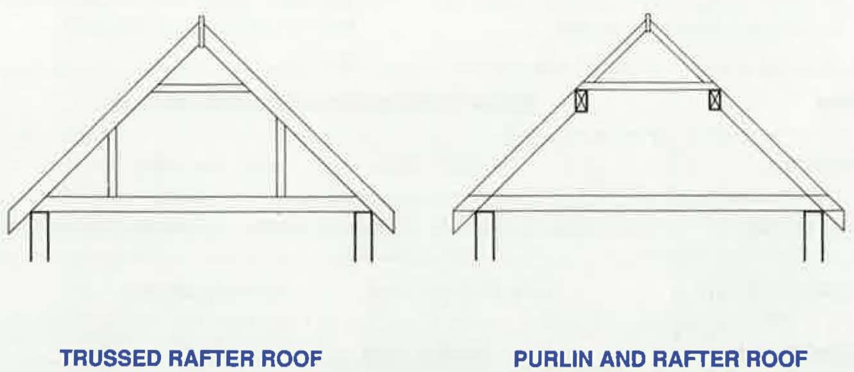


Structural systems for rooms-in-the-roof

"To accommodate the required thickness of insulation, it may be necessary to increase the depth of the rafter by adding timber battens on the inside"

CONSTRUCTION OPTIONS

The range of possible construction options for the roof structure, and the method of insulating the room-in-the-roof at rafter level is given in table 1.

Purlin and rafter roofs have the advantage that the purlins can be used to support extra deep rafters up to ceiling level in order to accommodate a greater thickness of insulation, whilst allowing smaller timbers to be used for the top triangle. Eaves cupboards are most easily formed with this type of construction. However, these roofs need to be specially designed and it may be preferable if eaves storage is not required to take advantage of the range of 'attic' trusses, now available from trussed rafter manufacturers (see Diagram 8).

Like conventional pitched roofs with lofts, roofs using 'attic' trussed rafters require diagonal bracing to resist buckling. The most difficult area of the roof in which to incorporate the bracing in sympathy with the insulation is at the inclined ceiling.

For a ventilated cold roof, it is possible to continue the line of the surface fixed diagonal bracing, but fix it between the rafters. Since the timber blocks to which the diagonal bracing is fixed are approximately the depth of the required 50 mm ventilation space, this allows the insulation to be installed from the inside of the building, once the roof is weather tight (see Diagram 9).

Diagonal bracing of 38 x 150 mm timber is probably most convenient, but 12 mm plywood can be used. The plywood need extend only over the area where the diagonal timber bracing would otherwise be located.

If sarking insulation is used, the diagonal bracing can be located conveniently between the rafters without affecting the insulation (see Diagram 13).

Plywood bracing can be fixed across the inside surface of the rafters at the inclined ceiling, if it is convenient to install the insulation from the outside.

The depth of the rafters in attic trusses are such that with a ventilated roof it may be necessary to increase the depth slightly with timber battens to accommodate the required thickness of insulation (see Diagrams 9 and 10).

As an alternative to adding timber battens to the rafters, and to avoid thermal bridging, it may be more effective to replace the normal plasterboard ceiling with insulating plasterboard (see Diagram 11).

DETAILING TO AVOID CONDENSATION WITHIN ROOF VOIDS

For ventilated cold roof designs, it is important that all roof voids are properly ventilated, ie not restricted and with appropriate openings at each end.

The amount of water vapour available to condense can be restricted by extracting it close to its source, and by sealing all holes in the lining and by introducing a vapour control layer on the inside of the insulation. The vapour control layer also acts as an air barrier which improves the airtightness of what would otherwise be a leaky construction.

The **key detailing points** follow.

Ventilated roofs

- A clear 50 mm deep ventilation path should be provided between the insulation and the sarking felt where the insulation is between the rafters.
- It is acceptable for mineral fibre insulation to wrap around the diagonal 'inter-rafter' bracing, provided it does not restrict the ventilation path.

MAIN TECHNICAL RISKS

The main technical risk with this form of construction is:

- **condensation within roof voids** if moist air from the dwelling passes through the inner lining and is unable to be ventilated to the outside.

- A ventilation opening equivalent to a 25 mm continuous gap should be provided at the eaves, with a 3-4 mm mesh to prevent the entry of insects. An opening equivalent to a 5 mm gap is required, either side of the ridge.
- A board or proprietary eaves ventilation tray should be used to maintain a 25 mm deep air path where insulation is draped over the wall plate.
- Ventilation can often be obtained below dormer windows via the bottom triangle of the roof or by using methods developed for ventilating monopitch roofs to achieve the equivalent of a 5 mm continuous gap.
- Ventilation openings equivalent to a continuous gap of 5 mm below, and 25 mm above a skylight window. It is difficult, if not impossible, to make such openings weatherproof and the only possible solution is to drill holes in the rafters above the level of the insulation to ventilate into adjacent roof voids. The structural implications of drilling the rafters in this position would need to be checked.
- A vapour control layer should be installed behind the inclined ceiling of the room-in-the-roof and behind the lining of other parts of the roof where ventilation is either restricted to a minimum or not possible, eg with hipped or other complicated roof shapes. The use of a vapour control layer in the walls to the lower triangles of the roof will improve the air tightness of the construction, provided it is not punctured by services or by doors to eaves cupboards.
- A vapour control layer is not necessary above the ceiling to the top triangle of a room-in-the-roof, provided all holes are sealed.
- The thickness of insulation needed between rafters can be reduced by additionally applying a continuous layer of insulation to the inside face of the rafters.
- If an insulated plasterboard is used as an inner lining, a separate vapour control layer is not necessary, provided there is an air seal at the skirting and holes for services are effectively sealed.
- If services are to be concealed and it is not possible to run them either within the insulation or between the insulation and the plasterboard, a services zone should be formed by fixing additional timber battens to the rafters. These battens may also serve to hold the insulation in position (see Diagram 10).
- Any space for services between the plasterboard lining or composite board and the main insulation must not be ventilated to the outside as this will render the insulation ineffective. The use of a vapour control layer/air barrier to the outside of the services zone will avoid the problem.
- Services behind roof linings should either be located in a position where they will not be damaged, or they should be suitably protected.

Insulated sarking

- Eaves cupboards and services can easily be accommodated between the sarking insulation and the plasterboard lining, without the need for a vapour control layer (see Diagram 12).
- All joints between boards and junctions with other elements of the construction should be sealed with polyurethane foam, sealant or tape.
- Insulation boards should be held down by fixing counter-battens to the rafters along the length of the insulation boards.
- A vapour permeable tiling underlay should be laid above the counter battens and fixed with tiling battens, making sure that the underlay is not in contact with the insulation.

SPECIFICATION NOTES

- Plywood for diagonal bracing of trussed rafters should be Bond Class WBP and Durability Class G or better.
- The vapour control layer should be 500 gauge polyethylene.
- Mineral fibre insulation which is to be installed from within the building should be paper faced to enable it to be self supporting.
- To ensure that skylight linings can be fitted as recommended by the manufacturer, the size of the skylight should be chosen to suit the rafter depth and its dimension along the inclined ceiling to the room.

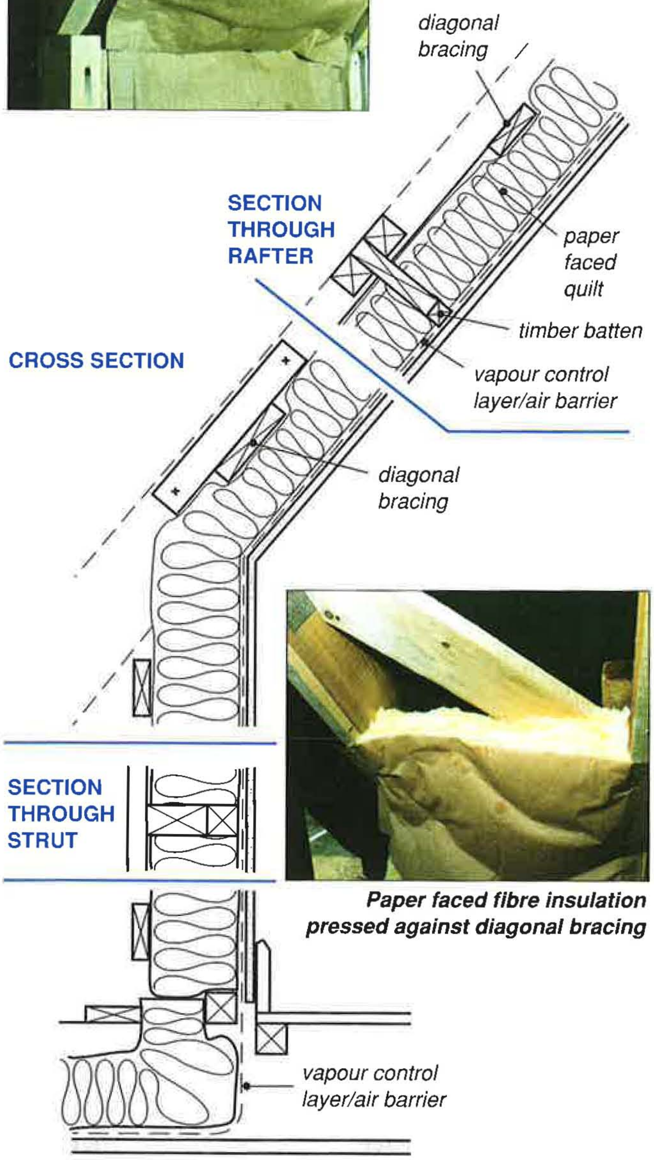
Items	Range of alternative construction options
Structure	trussed rafter / purlin and rafter
Bracing material	timber diagonal bracing / plywood panels / other wood-based panels
Insulation concept	ventilated cold roof / insulating sarking
Insulation material	mineral fibre / rigid plastics
Insulation position	between rafters / between and below / between and above / above rafters

Table 1 Construction options for room-in-the-roof designs

9 VENTILATED ROOF

MINERAL FIBRE INSULATION

Paper face of insulation quilt stapled to rafters



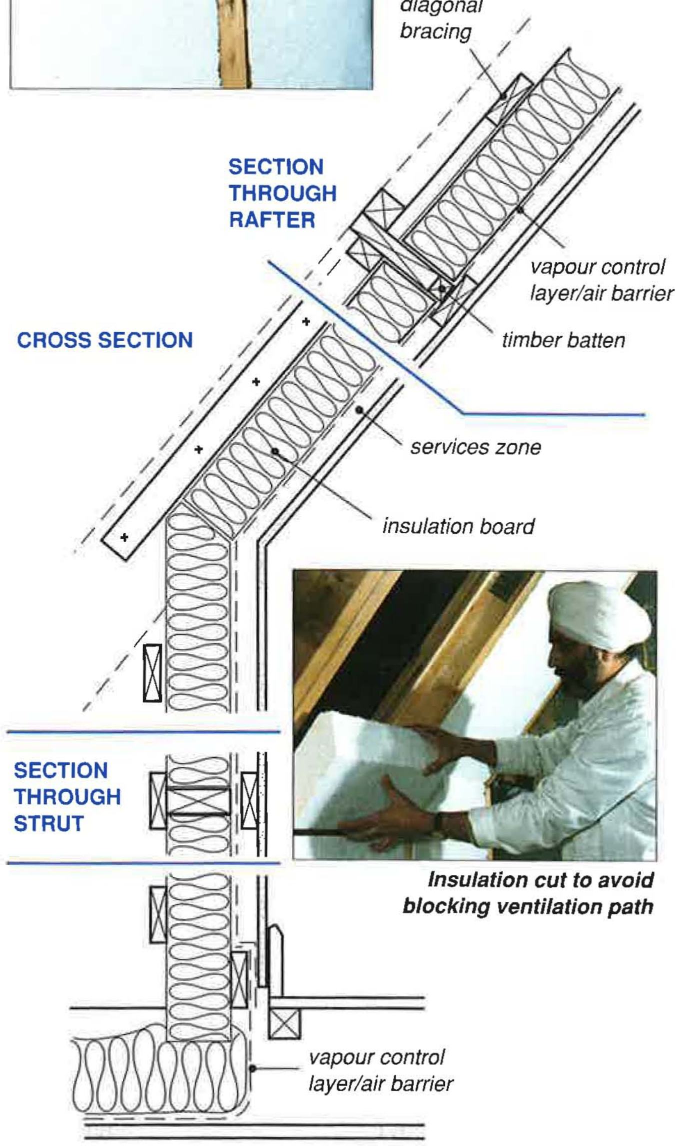
Paper faced fibre insulation pressed against diagonal bracing

Joining ceiling and roof vapour control layers/air barriers on a timber rail

10 VENTILATED ROOF WITH SERVICES ZONE

RIGID PLASTICS INSULATION

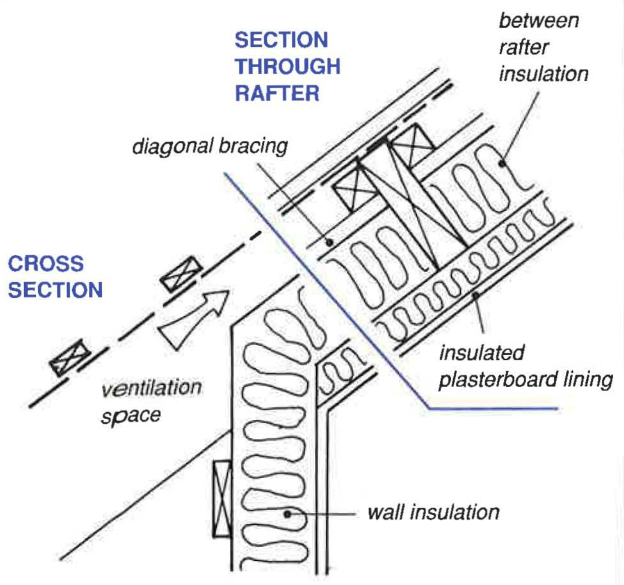
Timber spacing batten maintains ventilation path



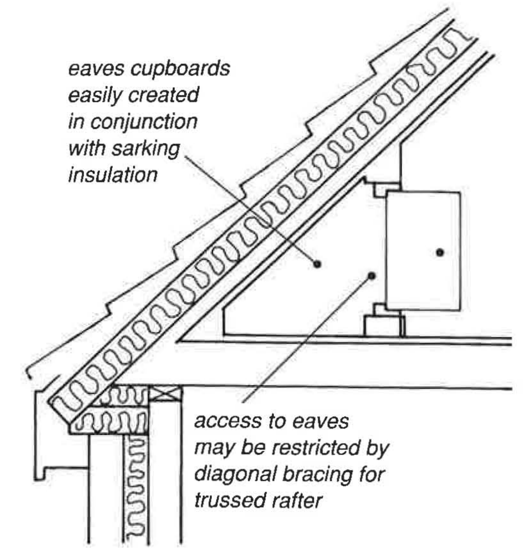
Insulation cut to avoid blocking ventilation path

Services zone created on the inside of the vapour control layer/air barrier

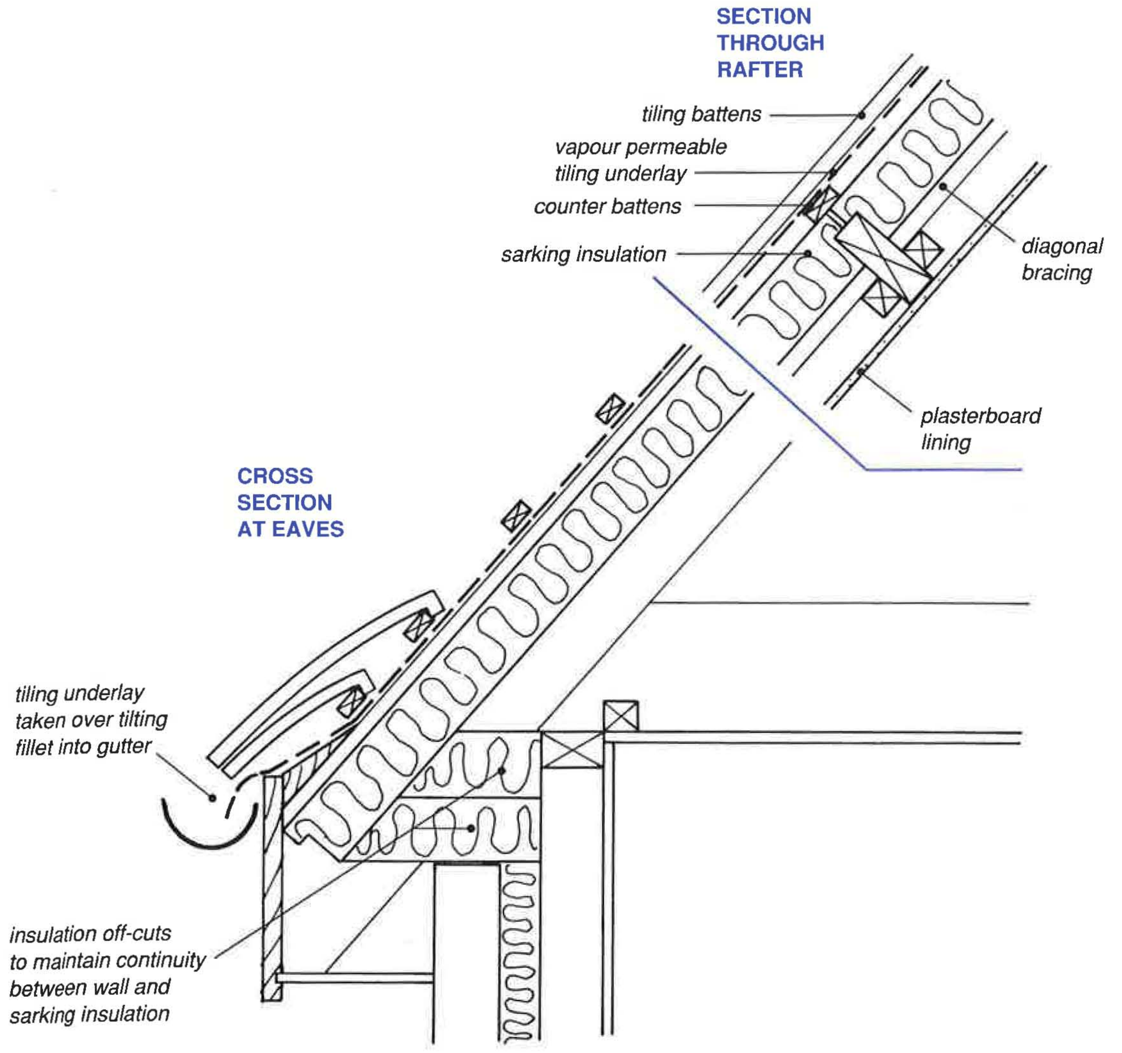
11 VENTILATED ROOF WITH INSULATED LINING



12 EAVES CUPBOARDS



13 SARKING INSULATION



ENERGY EFFICIENCY IN NEW HOUSING

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PITCHED ROOFS

Services in roof spaces

INTRODUCTION

Large roof voids are obvious places to route or locate services. Water storage cisterns have traditionally been located in the loft space. These, together with electrical cables, soil and vent pipes and, more recently, ventilation ducts, all present a number of technical risks.

MAIN TECHNICAL RISKS

The main technical risks with services in pitched roofs are:

- **air infiltration** through the holes and gaps around services that pass through the ceiling into the loft space
- **condensation in ventilation ducts** within the roof space if they are inadequately insulated
- **freezing of water** in pipes and storage tanks within the roof space if not adequately insulated
- **fire risk** from the overheating of electrical cables covered by insulation.

DETAILING TO AVOID AIR INFILTRATION

Warm moist air entering the roof space through gaps around services can result in condensation occurring on the cold surfaces within the roof. It is important, therefore, to seal the gaps around services that pass through the ceiling.

To minimise the number of service penetrations consider:

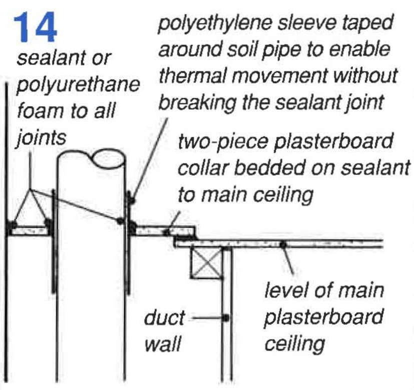
- designing the heating and cold water systems to eliminate water pipes and cisterns from the roof space, and
- fitting an air admittance valve (AAV) to the soil pipe above the highest sanitary appliance so that it can terminate below the ceiling level, provided it is in a ventilated duct to avoid damage and tampering.

The **key detailing points** follow.

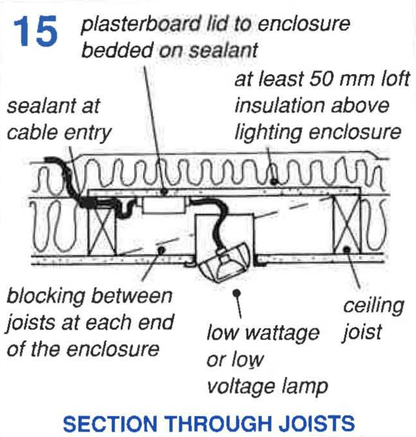
- Seal gaps around services such as pipes, ventilation ducts and electrical cables, as they pass through the ceiling to the roof space. This is particularly important above kitchens and bathrooms.
- Gaps less than about 6 mm wide can be filled with a suitable sealant, larger gaps with expanding foam.
- The method of sealing around soil pipes should allow for thermal movement (see Diagram 14).
- Avoid placing high wattage recessed light fittings at ceiling level. The air flow through the fitting which is needed to cool the lamp can transport moisture into the loft space.

FEATURES

- Water pipes and storage cisterns in the roof space should be insulated to prevent freezing. Alternatively, the heating and cold water systems could be designed so that there are no pipes or cisterns in the roof space.
- Ventilation ducts in the roof space should be insulated.
- Highly rated electrical cables should be located above the insulation or increased in size to prevent overheating.



Forming an airtight seal around a soil pipe



An enclosure to a recessed light fitting

- Recessed light fittings designed for compact fluorescent or low voltage tungsten halogen lamps can be used, provided they are contained within a sufficiently large enclosure to dissipate heat from the lamps (see Diagram 15).

> *"Consider designing heating and cold water systems so that there are no pipes or cisterns in the roof space"*

DETAILING TO AVOID CONDENSATION IN VENTILATION DUCTS

Where extract ducts from kitchens and bathrooms pass through the roof space, the warm, moist air being extracted can quickly cool below the dew point, condense on the duct wall and drip back into the room or the fan housing. The risk can be reduced by insulating the duct and by correct design of the ductwork.

The **key detailing points** follow.

- If a ventilation duct runs horizontally, it should fall towards the outside (see Diagram 16).
- If a ventilation duct rises vertically, it should be fitted with a condensation trap that is drained to the outside (see Diagram 16).
- Insulate the ventilation ducts with the equivalent of 25 mm or more of mineral wool.

DETAILING TO AVOID FREEZING OF WATER IN PIPES AND CISTERNS

Water pipes and storage cisterns in roof spaces are at risk of freezing if subject to low temperatures. The design should aim to locate as many pipes as possible within the insulated and heated enclosure of the dwelling. Alternatively consider designing a system which eliminates water pipes and storage cisterns from the roof space.

The **key detailing points** follow.

- Form an insulated enclosure around the storage cistern and link this with the roof insulation. To prevent contamination of stored water, the cistern should have a closely fitting cover, as well as a screened air inlet and overflow (see Diagram 17).
- When the water storage cistern is supported on a raised platform, extend the insulated enclosure as a shaft down to ceiling level so that the cistern receives heat from below.
- Where possible locate pipes within the insulated cistern enclosure or under the loft insulation, but avoid running hot and cold water pipes closely together, since this will warm the cold water supply too much. Insulate all pipes, including overflows, with pipe insulation.
- The rising main should always be insulated above ceiling level with pipe insulation with all joints covered with vapour resistant tape. This is to prevent condensation forming on the cold rising main and running down to stain the ceiling.

DETAILING TO AVOID THE RISK OF FIRE

Electrical cables that are enclosed by insulation may be unable to adequately dissipate the heat generated when a current passes through them, creating a risk of overheating.

The **key detailing points** follow.

- Design for electrical cables to be run on timber binders, bracing or battens within the cold roof space above the loft insulation.
- If the following circuits are covered by insulation, the cables should be increased in size:
  - 30 amp cooker control units
  - 30 amp radial circuits supplying 6 kW shower units or socket outlets.

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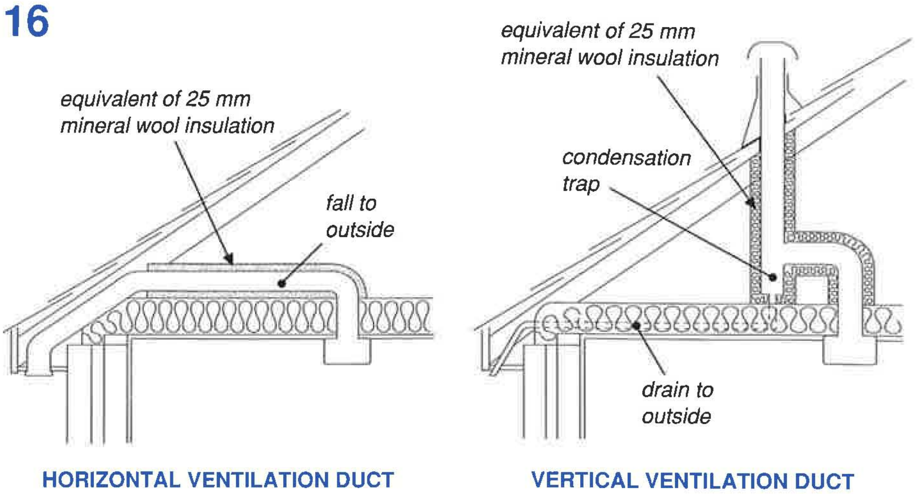

Detailing ventilation ducts in roof spaces

Pipe diameter	Thermal conductivity of pipe insulation [W/m·K]	
	0.035	0.04
15 mm	25 mm	32 mm
22 and 28 mm	19 mm	22 mm

Table 2 Minimum thicknesses of pipe insulation to delay freezing *(based on proposed revision to BS 6700)*

- Avoid contact between PVC sheathed cables and expanded polystyrene insulation, since this can cause the sheathing to become brittle, reducing its life expectancy.

SPECIFICATION NOTES

- Insulation materials used to insulate pipes and ducts within the roof space should preferably have a high resistance to water vapour. Suitable materials include closed cell rubber or polyethylene.
- The thickness of pipe insulation for water pipes in unheated roof spaces should be in accordance with table 2.
- A caulking sealant, such as acrylic, is suitable for sealing small gaps around services as they pass through the ceiling. Foamed polyurethane is recommended where gaps are larger or irregular in shape.

BUILDABILITY

- Gaps around cables serving ceiling roses should be sealed from above, after the rose has been wired and before loft insulation has been laid. This prevents sealant displacement during wiring up when cables are often pushed back up into the roof space.

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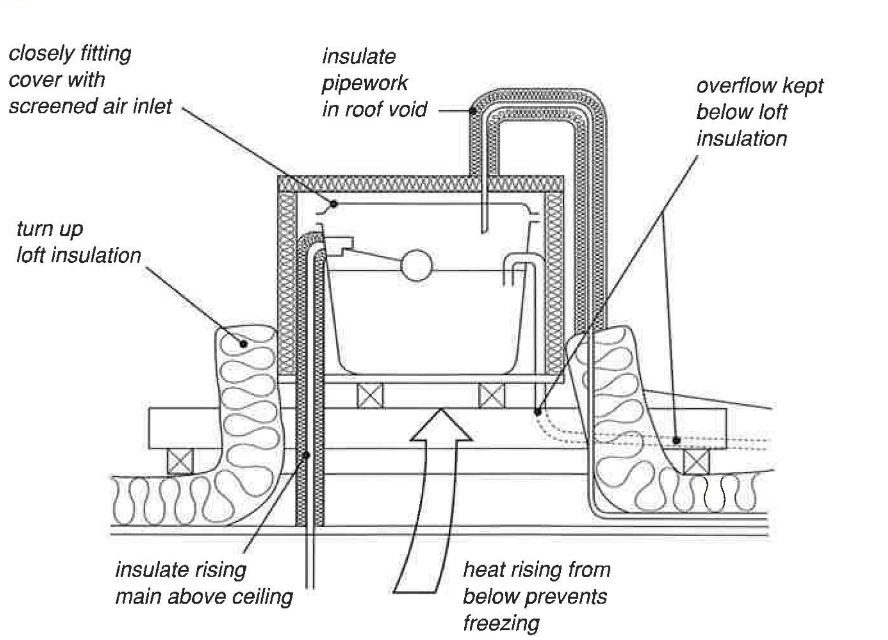

Detailing of insulation to water pipes and storage cistern